ADEQ
Arizona Department of Environmental Quality

Janet Napolitano, Governor
Stephen A. Owens, ADEQ Director

Pinto Creek
Site-Specific Water Quality Standard for Dissolved Copper

Salt River Watershed – HUC# 15060103-018
Gila, Maricopa and Pinal Counties, Arizona

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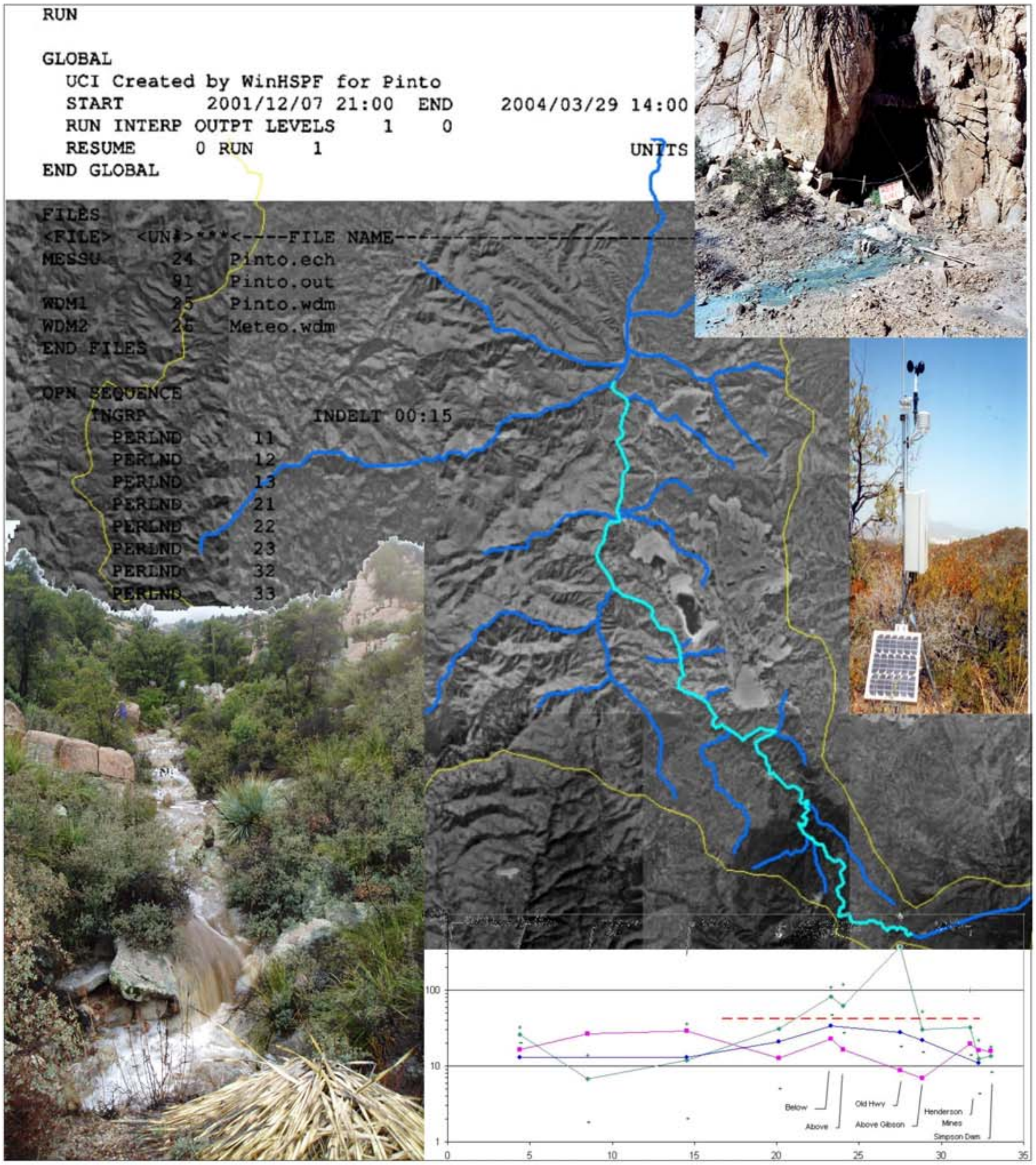

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LIST of ACRONYMS and ABBREVIATIONS

%	percent
A.A.C.	Arizona Administrative Code
A&Ww	Aquatic and Wildlife, warm water
A&Wc	Aquatic and Wildlife, cold water
A&Wedw	Aquatic and Wildlife, effluent dependent waters
A&Weph	Aquatic and Wildlife, ephemeral
ADEQ	Arizona Department of Environmental Quality
AgI	Agricultural Irrigation
AgL	Agricultural Livestock Watering
BHP-PVO	BHP Billiton - Pinto Valley Operations
CFR	Code of Federal Regulations
CFS	Cubic Feet per Second
CWA	Clean Water Act
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
FBC	Full Body Contact
FC	Fish Consumption
HSPF	Hydrologic Simulation Program Fortran
HUC	Hydrologic Unit Code
LA	Load Allocation
MPI	Malcolm Pirnie, Inc.
mg/L	milligrams per liter, equivalent to parts per million
MSL	Mean Sea Level
ND	Not Detected
NPDES	National Pollutant Discharge Elimination System
PERLND	Pervious Land Segments
PLS	Pregnant Leachate Solution
SSO	Site-Specific Objective (same as SSS)
SSS	Site-Specific Standard
SX/EW	Solvent Extraction/Electrowinning
TMDL	Total Maximum Daily Load
T&E	Threatened and Endangered Species
µg/L	micrograms per liter, equivalent to parts per billion
USFS	United States Forest Service
USGS	United States Geological Survey
USEPA	United States Environmental Protection Agency
WLA	Wasteload Allocation

Definitions

Natural Background, Natural Condition, or Pre-anthropogenic Water Quality – means the concentration of a pollutant in a surface water due only to non-anthropogenic sources.

Ambient Background Water Quality – The concentration of a water quality constituent in a surface water due to non-anthropogenic sources and anthropogenic sources that cannot be practically reduced.

Site Specific Criterion – A water quality criterion established for a specific water body, considering the local characteristics of that water body.

Site Specific Standard – A water quality standard established using a site-specific criterion

Pinto Creek
Site-Specific Water Quality Standard
for Dissolved Copper

1.0 Introduction

This document describes the data and methodology used to derive a Site-Specific Standard (SSS) for dissolved copper in Pinto Creek. The SSS is geographically limited to a 15.55 mile reach of Pinto Creek, and established at a concentration of 42 ug/L, which is equal to natural background conditions. The SSS criterion is not variable on the basis of hardness.

The data used to derive the SSS were obtained from 670 water quality samples collected at 48 sites by the Arizona Department of Environmental Quality (ADEQ) between the years 2000 and 2005. Of these water samples, approximately 217 were obtained from 26 sites in sub-watersheds judged to be representative of natural, pre-anthropogenic conditions. This information combined with numerous other environmental data was used to construct a dynamic watershed-water quality model of Pinto Creek. This model provided a tool by which pre-anthropogenic water quality for all of Pinto Creek could be estimated with a reasonable degree of confidence.

2.0 Project Background

Pinto Creek (HUC 15060103-018) appears on the State of Arizona's 1998 Clean Water Act (CWA) Section 303(d) listing of impaired waters, for exceeding the water quality standard for dissolved copper. Much of the data used for the listing was derived from field investigations conducted by ADEQ (circa 1990) of unauthorized discharges originating from the Gibson copper mine.

In 2001, the United States Environmental Protection Agency (USEPA) completed a Phase I Total Maximum Daily Load (TMDL) analysis of Pinto Creek (USEPA, 2001). This TMDL analysis appropriately attributed much of the copper load in Pinto Creek to discharges originating from the inactive Gibson mine facilities. Other specifically itemized load allocations included in the Phase I TMDL analysis were; Henderson Ranch mines (Figure 1), unknown sources below old Highway US 60, the Cactus Breccia formation, the proposed Carlota mine facilities, and the BHP Billiton - Pinto Valley Operations (BHP-PVO) National Pollutant Discharge Elimination System (NPDES) outfalls. In the Phase I model, USEPA set the natural background concentration at a uniform 10 ug/L (0.010 mg/L) dissolved copper for the entire Pinto

Creek watershed. The hardness, by which the Aquatic & Wildlife (A&W) dissolved copper criteria are based, was assumed to be 400 mg/L (USEPA, 2001).

Figure 1 - Tailings at Henderson Ranch Mines

Due to the limited available data on which the Phase I TMDL was based, ADEQ began a comprehensive field data collection program to provide data for a refined Phase II TMDL analysis. Early in the data collection phase, it was observed that copper was ubiquitous in the surface waters of the watershed. Many human-caused sources, predominantly from abandoned / inactive mines, were readily identified. Copper concentrations associated with these sources were found to be orders of magnitude greater than applicable water quality standards. Remarkably, elevated copper concentrations also persisted in several tributaries where no known sources of copper existed. Also observed were substantial spatial variations in hardness levels on which the A&W water quality criteria for dissolved copper are based (A.A.C. R18-11, Appendix A).

A majority of the surface waters with very low hardness values were observed in the upper portions of the watershed, resulting in very low dissolved copper criteria values in these areas. These areas of low hardness waters occurred coincidently with some of the copper-laden tributaries with no apparent anthropogenic sources of copper. This combination of elevated background copper levels and low hardness is considerably different than the assumptions made in the Phase I TMDL. During the early Phase II TMDL project, ADEQ began to hypothesize that natural background conditions alone exceed the criteria. Thus, deriving a TMDL that would meet the default copper criterion may not be achievable in portions of Pinto Creek.

In 2003, ADEQ conducted water quality monitoring of additional tributaries with no, or minimal, disturbances to confirm these findings. An initial attempt at watershed modeling in 2004 concluded that portions of Pinto Creek would exceed the default copper criteria, even if all human-caused sources were removed from the analysis.

In 2004, ADEQ reviewed additional data on land use, geology, and known abandoned mines to target and monitor additional sub-watersheds thought to represent undisturbed natural background conditions. ADEQ also attempted to obtain surface water samples specific to individual geologic units to derive a range of dissolved copper values in runoff from these lithologies. In 2004 and 2005, ADEQ collected samples from these tributaries during several moderately large precipitation events.

At this point, the watershed modeling effort took on two major objectives; 1) to perform the analysis needed for TMDL development, and 2) to generate a model scenario that estimated water quality in terms of pre-anthropogenic or natural background conditions.

This report summarizes the results of the data collection and modeling effort, and documents the process of deriving a recommended SSS for dissolved copper in Pinto Creek. Acknowledgment of the natural background condition and establishment of the SSS has been found to be necessary in order to complete the pending Phase II TMDL analysis of Pinto Creek.

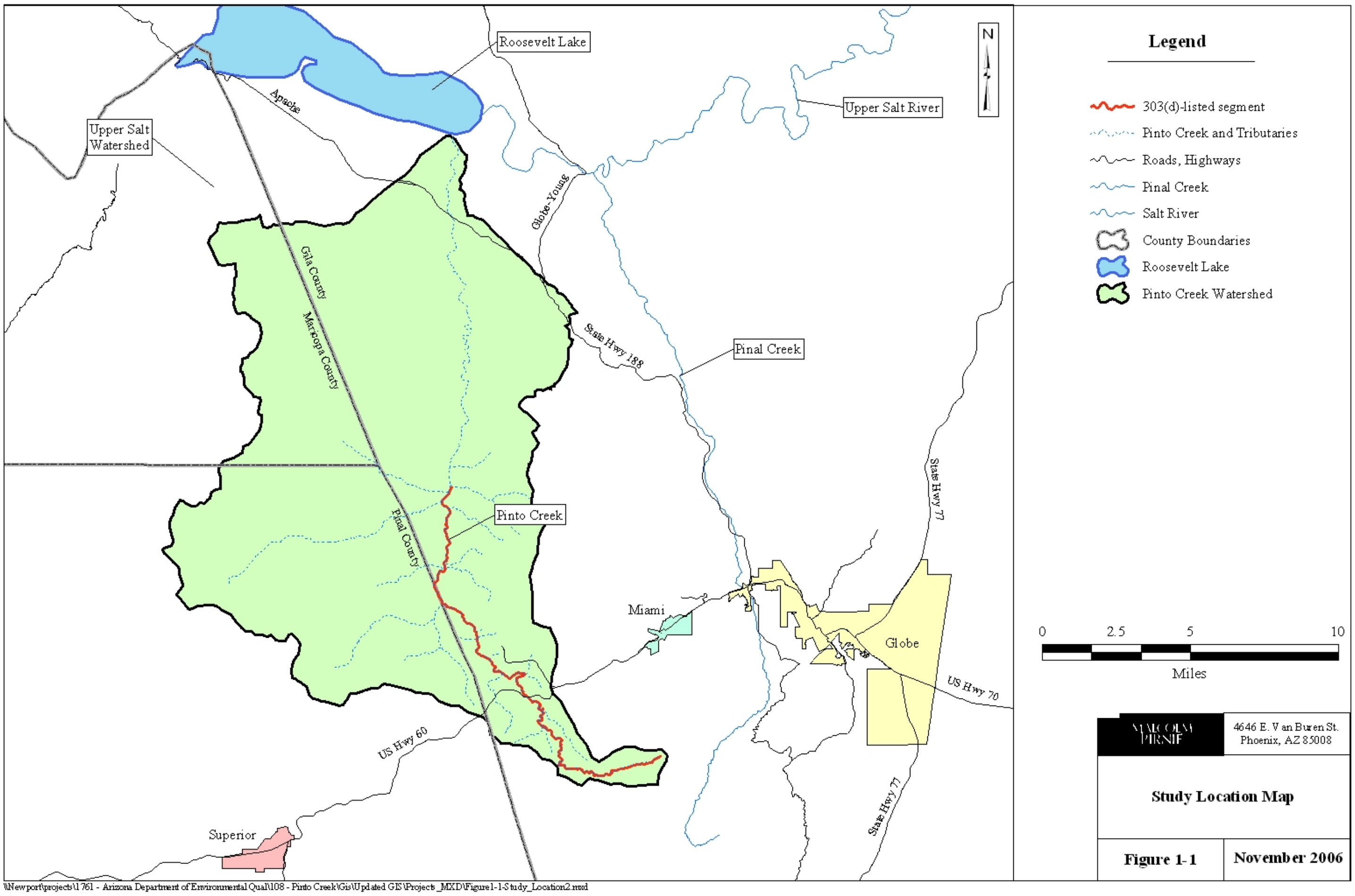
3.0 General Physical Setting

3.1 Physical Characteristics

Pinto Creek is a predominately intermittent stream that drains approximately 183 mi^2 in Gila, Pinal, and Maricopa counties in east central Arizona (Figure 2). The stream extends approximately 33 miles from its headwaters in the Pinal Mountains to Roosevelt Lake. Although much of the creek length is intermittent, it contains several perennial reaches where groundwater is forced to the surface by bedrock constrictions (MPI, 2006). Pinto Creek flows perennially in at least three reaches: from the confluence with Miller Gulch to a point downstream of the Haunted Canyon confluence; from a point below the Iron Bridge to a point above the West Fork of Pinto Creek confluence; and from the Pinto Valley weir to a point upstream from the Blevens Wash confluence (USEPA, 2001).

The Pinto Creek basin is generally characterized by thin soils and steep, rugged hills with surface elevations that range between 2100 and 6400 feet above mean sea level (MSL) (Figure 3) (MPI, 2006). The character of Pinto Creek changes significantly along the stream course. From its upper reaches to the Pinto Valley Weir, Pinto Creek and its tributaries have the characteristics of mountain stream channels, with relatively steep gradients, small flood plains, and coarse stream bed materials. In these areas, the stream is enclosed by steep, rugged terrain possessing only a thin soil cover. Due to the steep topography, thin soils and high stream gradient, the Pinto Creek is hydrologically flashy in nature. Below the Pinto Valley Weir, Pinto Creek transitions to flatter gradients, with wider floodplains as it continues toward Roosevelt Lake (USEPA, 2001).

Figure 2 – Study Location Map (MPI, 2006)



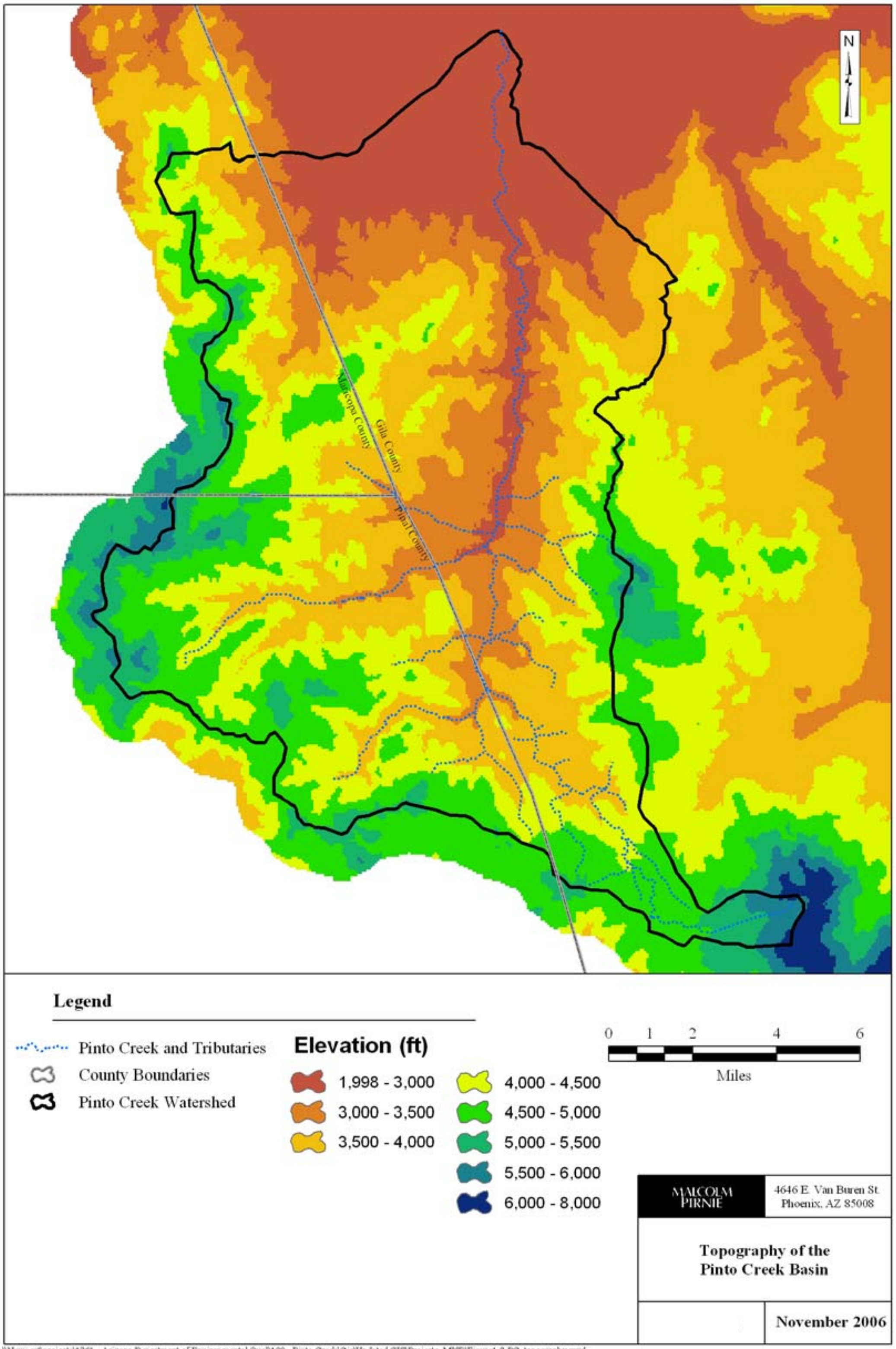
3.2 Land Use

Most of the Pinto Creek Basin (95 percent) consists of undisturbed land that is covered by a mixture of shrub and brush rangeland and evergreen forest, including portions of the Tonto National Forest. The other major land cover is stockpile material from mining facilities, which covers about 5 percent of the Pinto Creek Basin. Buildings, roads, and paved areas represent a minimal portion of the watershed (MPI, 2006).

3.3 Physiographic Setting

Pinto Creek is located on the northern margin of the Basin and Range physiographic province which is typified by alluvium-filled valleys separated by elongated fault-blocked mountain ranges (Hunt, 1974). Pinto Creek originates in the Pinal Mountains, and flows northerly toward Roosevelt Lake, a man-made reservoir located in the Salt River valley.

Figure 3 – Watershed Elevation Map (MPI, 2006)



3.4 Mining History

Figure 4 - BHP-PVO - Dump Leach Stockpile and PLS Pond

Pinto Creek flows across the western margin of the historic Globe-Miami mining district, one of the major porphyry copper districts in the southwestern United States (USEPA, 2001). Due to the natural copper mineralization, the basin contains numerous historical mining-related disturbances including open pits, tunnels, waste rock and tailings piles, leach dumps, and milling facilities. The largest mining operation in the watershed is the BHP Billiton - Pinto Valley Operations, which is not currently mining ore but operates existing leach stockpiles and maintains Solvent Extraction/Electrowinning (SX/EW) facilities (Figure 4). Many of the BHP operations have been impounded to prevent surface discharge to Pinto Creek during storms smaller than the 100-year, 24-hour events (MPI, 2006). A more detailed synopsis of historic mining activities is available in the Phase I TMDL for Pinto Creek (USEPA, 2001).

3.5 Geologic Setting

The headwaters of the Pinto Creek basin are underlain by schist and granite (Figure 5). Various other lithologies outcrop throughout the basin, including dacite, diabase, and sedimentary rocks of the Apache Group that include sandstones, shales, and limestones. The Cactus Breccia copper ore body crops out in a small area in and near the Pinto Creek channel. This ore body has been extensively mined on the east side of Pinto Creek and is the target of the proposed Carlota Copper Project (Figure 6). Portions of the creek channel are underlain by alluvial sediments (MPI, 2006).

Figure 5 – Surface Lithology of the Pinto Creek Basin (MPI,2006)

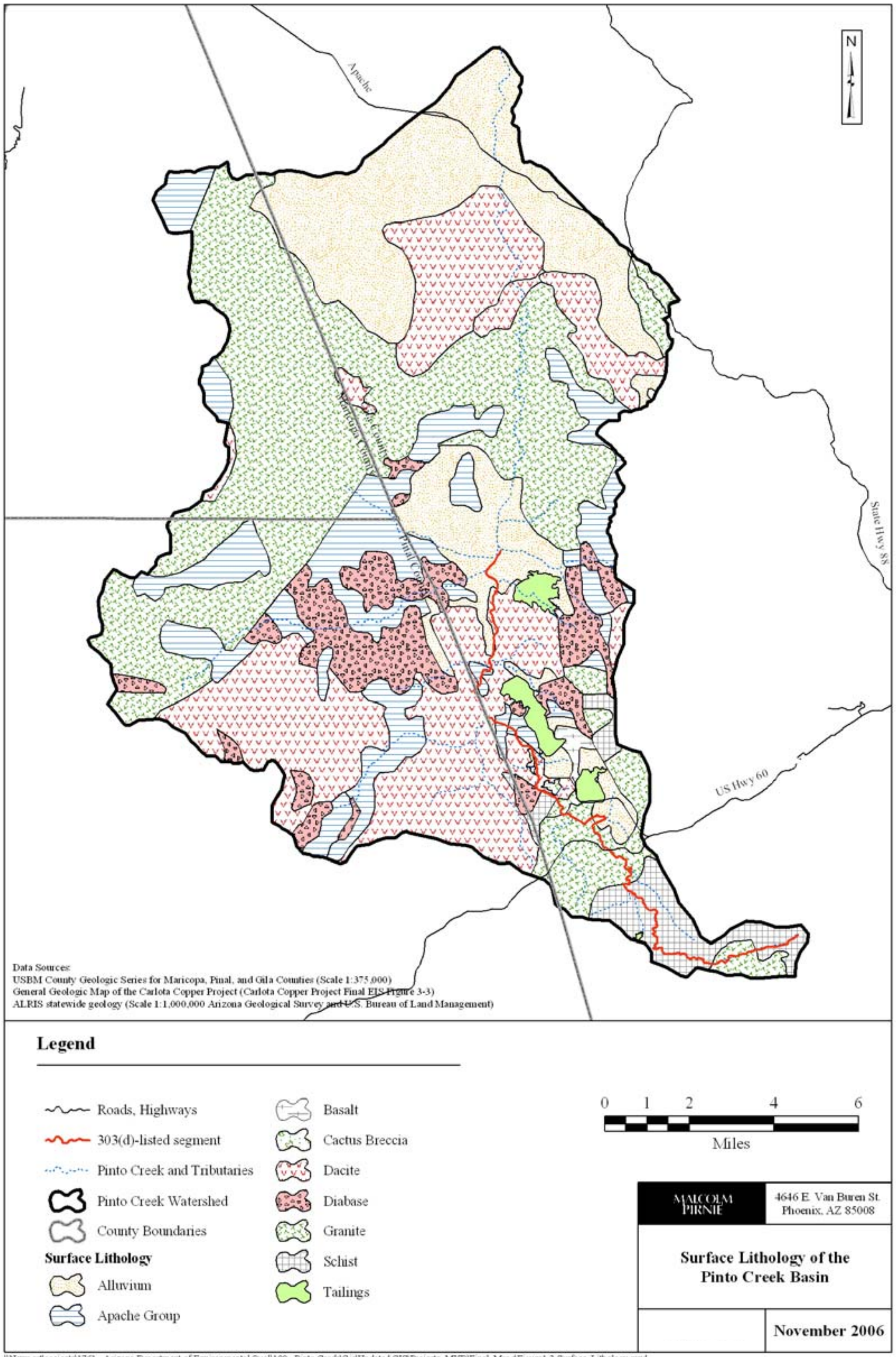
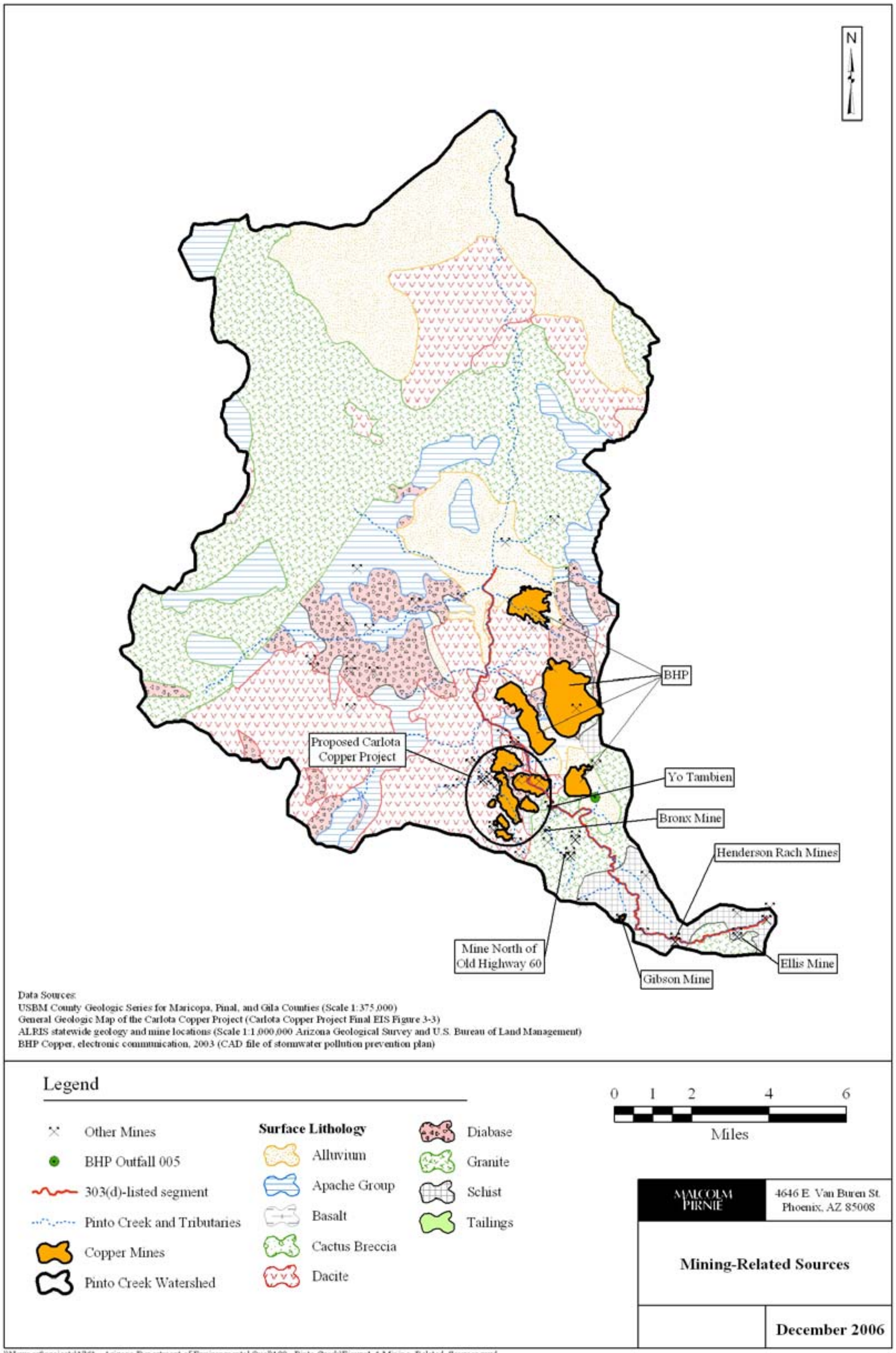


Figure 6 – Mining Related Sources in the Pinto Creek Basin (MPI,2006)



3.6 Climatic Setting

The climate of the Pinto Creek watershed is characterized by warm summers and mild winters. Average annual precipitation measured at the BHP-PVO mine from 1973 thru 1995 is approximately 23.8 inches, and has ranged from 10.2 to 41.2 inches annually (USFS, 1997). Increased precipitation is received in July and August as the result of convective, short duration, monsoon thunderstorms. A second rainy season occurs in winter (December through March), and is associated with low pressure storm fronts moving into Arizona from the Pacific Ocean. (Sellers, W.D., Hill, R.H, 1974). Snowfall is common in the higher elevations of the watershed during the winter months.

3.7 General Watershed Information

TABLE 1 - ***General Watershed Information***

Waterbody Name	Pinto Creek
Waterbody HUC ID	15060103-018
Total Stream Length	Approx. 33 mi
Total Area of Drainage Basin	Approx. 183 mi^2
Watershed Location	Gila, Maricopa and Pinal Counties, Arizona
Latitude/Longitude	N33º 25' 00" W110º 61' 00"
303(d) Listed Reaches	HUC 15060103-018A - Not attaining (4A) HUC 15060103-018B – Impaired (5) HUC 15060103-018C – Impaired (5)
Stressor	Copper (dissolved)
NPDES Permitted Facilities	BHP-PVO (existing), Carlota Copper Co. (proposed)
Nearest Communities	Miami, Globe and Superior, Arizona
Major River Basin	Salt River
Designated Uses	Aquatic and Wildlife (A&W), Fish Consumption (FC), Full Body Contact (FBC), Agricultural Irrigation (AgI), and Agricultural Livestock Watering (AgL).

TABLE 2 - *Current Designated Uses and Numeric Water Quality Criteria for Copper Applicable to Pinto Creek*

Stream	A&Wcold (Dissolved Cu µg/L)[1]	A&Wwarm (Dissolved Cu µg/L)[1]	FBC (Total Cu µg/L)	FC	AgI (Total Cu µg/L)	AgL (Total Cu µg/L)
Pinto Creek Headwaters to confluence with unnamed tributary at 33º 19' 27" (15060103-018A)	Acute 3.64 – 49.62 Chronic 2.74 – 29.28	N/A	1,300	No Numeric Standard Copper	5000	500
Pinto Creek below confluence with unnamed tributary at 33º 19' 27" to Roosevelt Lake. (15060103-018B, 15060103-018C)	N/A	Acute 3.64 – 49.62 Chronic 2.74 – 29.28	1,300	No Numeric Standard Copper	5000	500

[1] = Standard is dependent on hardness (18 A.A.C.11, Article 1, Appendix A)

4.0 Regulatory Framework for Developing a Site-Specific Standard

USEPA policy acknowledges that natural background conditions may exceed default numeric standards, and thus warrant establishment of site-specific aquatic life criteria (USEPA, 1997). This policy requires that States define the meaning of "natural background" and specify or reference the procedures for determining natural background. The policy also states that site-specific criteria may be set equal to the natural background condition.

Pursuant to the USEPA policy, ADEQ has proposed rules for adopting site-specific water quality standards. At the time of this writing, ADEQ has proposed the following draft language concerning development of site-specific standards based on the natural background condition. If promulgated, the rule is expected to be found in the Arizona Administrative Code (A.A.C.) under R18-11-115;

> *R18-11-115. Site-Specific Standards*
> *A. The Director shall adopt a site-specific standard by rule. Site-specific standards are listed in Appendix C.*
> *B. The Director may adopt a site-specific standard for any of the following reasons:*

1. Local physical, chemical, or hydrological conditions of a surface water such as pH, hardness, or temperature alters the biological availability or toxicity of a pollutant;
2. The sensitivity of resident aquatic organisms that occur in a surface water to a pollutant differs from the sensitivity of the species used to derive the numeric water quality standards to protect aquatic life in Appendix A;
3. Resident aquatic organisms that occur in a surface water represent a narrower mix of species than those in the dataset used by the Department to derive numeric water quality standards to protect aquatic life in Appendix A; or
4. The natural background concentration of a pollutant is greater than the numeric water quality standard to protect aquatic life prescribed in Appendix A.
C. Site-specific study. A person shall conduct a site-specific study to support the development of a site-specific standard using the applicable procedure listed in subsections (D)(1) through (4):
1. The Recalculation Procedure, Appendix L, pages 90 - 98, Water Quality Standards Handbook, Second Edition, EPA 823-B-94-005b, August 1994. This material is incorporated by reference and does not include any later amendments or editions of the incorporated material. A copy of the incorporated material is available for inspection at the Arizona Department of Environmental Quality, 1110 W. Washington, Phoenix, Arizona 85007 or: may be obtained from the U.S. Environmental Protection Agency, Office of Water at http://www.epa.gov/waterscience/standards/handbook/ handbookappxL.pdf.
2. Water-Effects Ratio for Metals, Appendix L, pages 1 - 89, Water Quality Standards Handbook, Second Edition, EPA 823-B-94-005b, August 1994. This material is incorporated by reference and does not include any later amendments or editions of the incorporated material. A copy of the incorporated material is available for inspection at the Arizona Department of Environmental Quality, 1110 W. Washington, Phoenix, Arizona 85007 or: may be obtained from the U.S. Environmental Protection Agency, Office of Water at http://www.epa.gov/waterscience/standards/handbook/ handbookappxL.pdf.
3. Streamlined Water Effects Ratio Procedure for Discharges of Copper, EPA-822-R-01-005, March 2001. This material is incorporated by reference and does not include any later amendments or editions of the incorporated material. A copy of the incorporated material is available for inspection at the Arizona Department of Environmental Quality, 1110 W. Washington, Phoenix, Arizona 85007 or: may be obtained from the U.S. Environmental Protection Agency, Office of Water at http://www.epa.gov/ost/criteria/copper/copper.pdf.
4. Natural background.
a. A person seeking to develop a site-specific standard based on natural background shall provide a study outline to the Director and obtain approval before conducting the study.
i. The person may use statistical or modeling approaches to determine natural background concentration.
ii. Modeling approaches include Better Assessment Science Integrating Source and Nonpoint Sources (Basins), Hydrologic simulation Program-Fortran (HSPF), and Hydrologic Engineering Center (HEC) programs developed by the U.S. Army Corps of Engineers.
b. The Director may establish a site-specific standard at a concentration equal to the natural background concentration.
c. For purposes of this subsection, "natural background" means the concentration of a pollutant in a surface water due only to non-anthropogenic sources.

USEPA policy and support documentation state that site-specific criteria must be based on sound scientific rationale (USEPA, 1997, USEPA, 2005). However, there is little published guidance available on the methodologies or procedures for determining natural background conditions. One document *"USEPA Region 10 Natural Conditions Workgroup Report on Principles to Consider When Reviewing and Using Natural Conditions Provisions"* (USEPA 2005), lists the following key principles of natural background determinations:

- *geographically specific;*
- *scientifically defensible;*
- *well-documented and supported with data and information;*
- *highlighted in a process that provides the public an opportunity for review and comment when natural condition provisions are applied;*
- *tracked and accessible to the public.*

5.0 Generalized Technical Approach

The USEPA document referenced above suggests two fundamental approaches to determination of natural conditions; 1) measurement approach, and 2) modeling approach (USEPA, 2005).

The measurement approach assumes that the watershed is already free of anthropogenic sources. Further, the measurement approach requires water quality data sufficient to statistically characterize the stream under a range of flow and seasonal conditions.

The modeling approach requires a model code and input data commensurate with the complexity of the watershed hydraulics and pollutant being analyzed. Typically the model is calibrated to the available current condition data, and then modified to estimate eventual conditions. This process is also called "negative elimination" - estimating eventual conditions after quantifying and eliminating anthropogenic inputs (i.e, removing human impacts and then setting what remains as a "natural condition") (USEPA, 2005).

ADEQ's method for estimating natural background for Pinto Creek is the modeling approach, supplemented with a substantial set of water quality data judged to be representative of natural background conditions.

A dynamic non-point source model, HSPF (Hydrologic Simulation Program Fortran) version 12 (Aqua Terra Consultants, 1997), was employed to calculate existing loads, predict future conditions under various storm events, and evaluate potential remedial or new source scenarios. The HSPF model is well known and supported by USEPA for TMDL development and is included in USEPA's BASINS version 3.x (Better

Assessment Science Integrating Point and Nonpoint Sources) (USEPA, 2001) HSPF is arguably the most robust dynamic watershed model available. The HSPF model also offers the ability to simulate pre-anthropogenic watershed conditions, by removing all human-caused pollutant sources from the current conditions model. The resulting model is representative of natural background conditions.

After changing the current calibrated model to a natural background model, the basic steps to arriving at the SSS are:

1. Comparing the default water quality criteria and model predicted natural condition water quality ,
2. Determining the length of the SSS reach by identifying the specific reach which is "naturally" greater than the default standard, and
3. Determining the new criterion for the reach by estimating the peak natural condition concentration.

6.0 Water Quality Data

The data used to derive the SSS includes 670 stream water quality samples collected at 48 sites by the Arizona Department of Environmental Quality (ADEQ), predominantly, between the years 2000 thru 2005. Refer to the water quality data and monitoring site information located in Appendix A. Of these water samples, approximately 217 were obtained from 26 sites in sub-watersheds judged to be representative of natural, pre-anthropogenic conditions.

6.1 Natural Background Lithologies

6.1.1 Pinal Schist

The quality of surface water runoff from the Pinal Schist bedrock lithology (Figure 7) was assessed in nine locations. A minor unit of non-schist granodiorite outcrops in the headwaters of the "Ellis" tributary and is included in this grouping of natural background conditions of the Schist lithology. A total of 81 samples were collected by manual grab and automatic sampler methods. The average dissolved copper concentration of all samples collectively is 37.7 ug/L, with a standard deviation of 16.3 ug/L. The observed minimum and maximum concentrations were 18 ug/L and 96 ug/L respectively. On a single-mean-value-per-site basis, the average dissolved copper concentration is 32 ug/L, with a standard deviation of 6 ug/L.

Figure 7 - Pinal Schist along Pinto Creek 1/5/05

In the late summer of 2004, a wildfire burned portions of the Mead Canyon and “Ellis” tributary (Figure 8) sub-basins. Only one of 27 samples, from the two sample sites in the “Ellis” tributary sub-basin, was obtained downgradient of the burn area and after the fire. This sample had an identical dissolved copper concentration (26 ug/L) as a pre-fire sample taken at that location. Of the samples obtained from the two sample sites in Mead Canyon, 19 of 20 were post-fire samples, but still exhibited a moderately low mean dissolved copper level of 37 ug/L.

Figure 8 Burned Area in the "Ellis Ranch" Subbasin 10/22/04

6.1.2 Schultz Granite

Surface waters originating from the Schultz Granite bedrock lithology (Figure 9) were assessed in five locations. A total of 72 samples were collected by manual grab and automatic sampler methods. The average dissolved copper concentration of all samples was 50.6 ug/L, with a standard deviation of 13.3 ug/L. The observed minimum and maximum concentrations were 13 ug/L and 72 ug/L respectively. On a single-mean-value-per-site basis, the average dissolved copper concentration is 36.2 ug/L, with a standard deviation of 13.3 ug/L.

Figure 9 - Schultz Granite - with 5-Point Mountain in background 10/22/04

6.1.3 Other Bedrock Lithologies

The remaining data used for the natural background condition modeling includes sample sites on major tributaries in the middle portions of the Pinto Creek basin below US Highway 60 including; Powers Gulch, Haunted Canyon, “Mowing Machine” Basin, and the West Fork Pinto Creek. Most of these sites characterize sub-basins with mixed bedrock lithologies including; the sedimentary Apache Group, basalt, dacite, diabase, and surficial alluvium (MPI, 2006).

On the basis of mapping of known mines, there is the potential for anthropogenic copper sources to influence some of the background data, especially the Powers Gulch sub-basin. ADEQ would have preferred to obtain more samples from this area, however access to this area is difficult in dry conditions, and practically impossible during stormflow conditions. While there is the potential for some anthropogenic bias in this data, it is assumed to be limited to a few sub-basins such as Powers and Gold Gulch basins. These tributaries do not enter Pinto Creek until points below the projected maximum copper concentrations (i.e., below the Cactus / Carlota ore body). Thus, the only potential effect on the SSS that could be anticipated by collecting additional data would be to slightly reduce the distance downstream at which the default dissolved copper standard is met.

The analytical results for several locations in this group reported values as "not-detected" by the laboratory. For purposes of this analysis, a value of ½ of the detection (e.g., detection, reporting, or method) limit is used to calculate the statistics.

The water quality of runoff from the various mixed bedrock lithologies was assessed in eleven locations. A total of 78 samples were collected by manual grab and automatic sampler methods. The average dissolved copper concentration of all samples is 13.4 ug/L, with a standard deviation of 8.5 ug/L. The observed minimum concentration was not-detected (ND) (e.g., less than 10 ug/L), of which there were 17 ND's in the data set. The maximum observed concentration was 43 ug/L. On a single-mean-value-per-site basis, the average dissolved copper concentration is 17.7 ug/L, with a standard deviation of 8.6 ug/L.

7.0 Model Application to the Pinto Creek Watershed

The Pinto Creek watershed is predominantly mountainous in nature, and requires a dynamic watershed model with a relatively short time-step to simulate the complex and flashy nature of Pinto Creek's flow and copper loading. The model needed to simulate the different hydrologic characteristics and metals loading associated with different land covers and lithologies, as well as in-stream transport processes. The HSPF model code is well suited for this type of analysis.

The complexity of the Pinto Creek watershed required subdividing it into 41 subbasins. These subbasins were further divided into nine land cover types based on geology or land use, resulting in 149 pervious land segments (PERLND's). These PERLND's each have various acreage, physical and chemical characteristics assigned.

The HSPF model is a data intensive model requiring extensive time-series data on weather conditions, streamflow and water quality to be used successfully. These data sets were largely populated by automated weather stations, water samplers and stream gage equipment deployed by ADEQ and two stream gages maintained by the United Stated Geological Survey (USGS).

Numerous other input parameters are required to be set in the runoff, pollutant loading, channel hydraulics, and in-stream transport modules of the HSPF model. These input parameters are adjusted during the calibration phase of model construction.

A detailed discussion on the data sources, conceptual model, model selection, model design, calibration and results is located in the modeling report in Appendix B.

8.0 Model Assumptions

8.1 Potential Non-Reversible Human Induced Copper Loading Sources

ADEQ has considered the potential for several human-caused sources of copper in the sub-watersheds that have been sampled and deemed representative of natural background. These potential influences include roads, road cuts (section 8.1.1) and aerial deposition (section 8.1.2).

8.1.1 Roads and Road Cuts

ADEQ has observed in some other TMDL studies, roads and road cuts, into acid generating bedrock, can cause significant to serious water quality issues. It is acknowledged that several watersheds where ADEQ obtained natural background samples have some minimal land disturbance from roads or jeep trails. However, ADEQ does not believe that these minor land disturbances have influenced the natural background data to any detectable degree, because there are examples of data from sub-watersheds with roads with appreciably lower copper levels than other sub-watersheds with no apparent roads.

Consider the following three natural background sites all within the schist bedrock lithology. Site 102654 has a dirt road with road cuts along the entire watercourse and a mean dissolved copper level of 24 ug/L; whereas roadless site 102653 was 45 ug/l and roadless site 102650 was 34 ug/L (refer to the Data Sheets in Appendix A). On the basis of examples like these, ADEQ concludes that although a few of the natural background sample sites have some minor roads or jeep trails within their sub-watershed, there is no discernable increase in dissolved copper as a result of these disturbances.

8.1.2 Aerial Deposition

Aerial deposition of copper from active or historical mine facilities and smelters was considered as a potential non-reversible, human induced, source of copper loading. Particulate deposition from mine facilities would reasonably be possible from the BHP-PVO mine located within the Pinto Creek watershed. Other potential sources outside of the watershed include open pit mining and smelting facilities in the Globe-Miami area approximately 5 miles easterly, Ray-Hayden area approximately 30 miles southerly, and in Superior approximately 10 miles westerly of the Pinto Creek watershed. Metropolitan Phoenix is another potential source of copper containing particulates located approximately 60 miles westerly of the Pinto Creek watershed.

Locally, the prevailing surface wind direction in the watershed is predominantly from a southeasterly direction (USFS, 1997, EIS, p3-8). If aerial deposition were a significant source of copper from the BHP-PVO mine or other regional sources, it might be expected that monitoring sites located northwesterly of the BHP-PVO mine would exhibit elevated copper values. Considering that sites such as the long-term ADEQ monitoring site 100346, as well as sites 102435 and 102434 typically exhibit some of the lowest copper levels the watershed and are frequently below detection limits, ADEQ concludes that the impact of aerial deposition of copper from local or regional sources is not a measurable factor in this analysis of watershed conditions (refer to the Data Sheets in Appendix A).

8.2 Other Assumptions

Figure 10 - Yo Tambien Tunnel

Assumption #1 - Abandoned/inactive mines were modeled as non-point sources and assigned uniform areas of 5 acres (except Gibson which is approximately 15 acres).
Rationale: The HSPF model is a dynamic watershed model by which "non-point sources" rely on precipitation to generate runoff. Therefore, some surface area is required in order for the model to generate a pollutant discharge. It is acknowledged that several of the mine facilities (i.e., Yo Tambien (Figure 10), Bronx mines) are primarily known for having direct discharge from their adits. These adits could potentially be modeled as "point sources", as opposed to mine dumps or tailings (which are normally modeled as non-point sources). However, while precipitate copper stains were observed on the ground at the adit exits, no active flow was observed, even after relatively large storm events. This is likely due to the drought

conditions of the past few years, and as a result, groundwater elevations have likely declined. Therefore, in order to include a "source" in the model that would respond to precipitation events, and to facilitate various changes in model scenarios, the minimal 5 acre surface areas were assigned.
Implications: In general, ADEQ considers this is an environmentally conservative approach.

<u>Assumption #2</u> – Discharge concentrations from abandoned/inactive mines were reassigned for the ambient/background scenario model to a level equal to 10 times the natural background value assigned for the area surrounding the site.
Rationale: These small mines were presumably discovered by prospectors observing some copper mineral expression at the surface. Therefore, it is a reasonable assumption that the concentrations of copper from these mine areas are higher than the surrounding area.
Implications: It is acknowledged that this assumption is not the most environmentally conservative approach available. While the assumption is somewhat arbitrary, ADEQ believes it a reasonable one, and is certainly more realistic than reverting the mine areas in the natural condition model to the same concentrations as areas with less surficial expression of copper mineralization.

<u>Assumption #3</u> - Permanent hydrologic alterations in the "Current/Calibration" model are retained in the ambient/background model. Specifically, these consist of those portions of the basin occupied by the BHP PVO which are effectively hydraulically isolated from Pinto Creek.
Rationale: BHP PVO is a medium sized open pit mine with associated tailings piles and leach dumps. Stormwater from the mine site is retained and managed on-site in retention ponds which do not normally discharge to Pinto Creek. This stormwater retention is expected to continue in perpetuity. If the area of the BHP PVO mine were to be included in the ambient/background model, it would have required additional assumptions on hydraulic and pollutant fluxes over a substantial area in the middle Pinto Creek basin, which could not be readily be measured or verified.
Implications: In general, ADEQ considers this is an environmentally conservative approach. It could be argued that by including the BHP PVO area in the model, more dilution would occur from additional stormwater contribution. This in turn could potentially have the effect of reducing the required length of the SSS reach. However, because the mine is located on an extensive copper ore body, in all likelihood this additional flow would contribute even more copper per unit area to the stream than is currently included in the ambient/background model.

<u>Assumption #4</u> – When comparing the model predictions at the USGS Gage on Pinto Creek below Haunted Canyon to the A&W chronic standard, a hardness of 150 mg/L was use to calculate the criterion, instead of the mean of all samples (477 mg/L). The A&W chronic standard for dissolved copper is 12.66 ug/L at a hardness of 150.
Rationale: An analysis of the variability of hardness at this location indicates substantially lower hardness levels of approximately 150 mg/L during stream flows greater than 10 cfs (cubic feet per second). Since the model was designed and

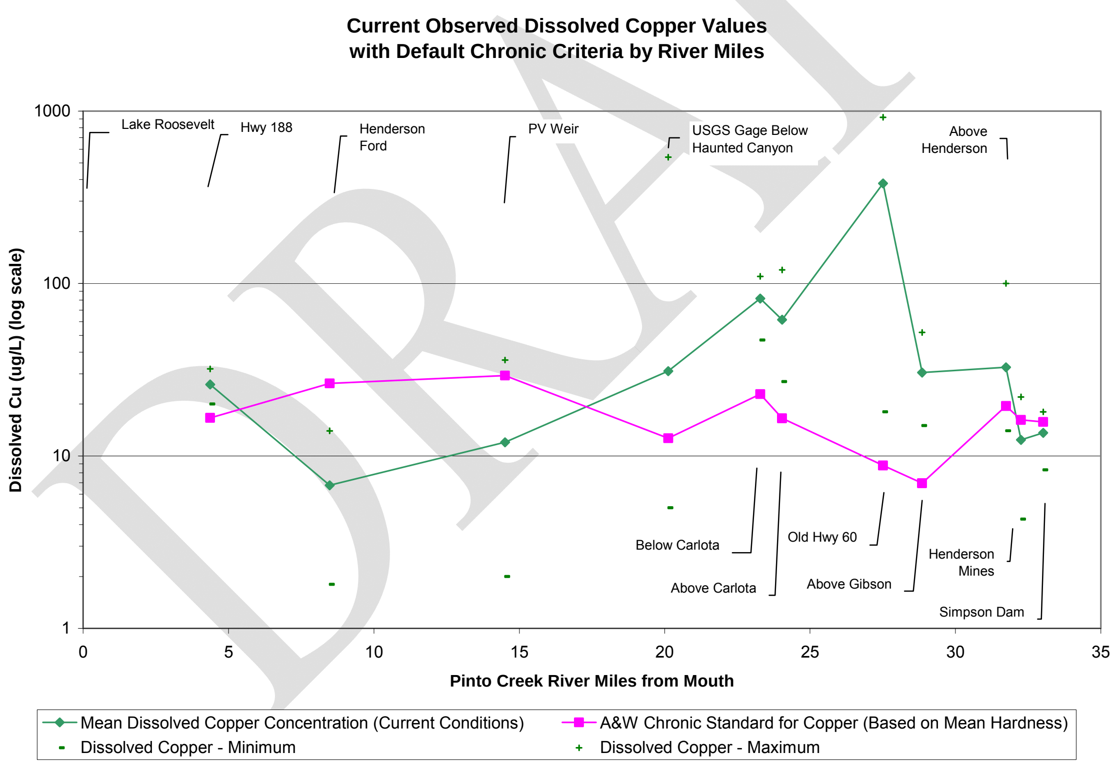
calibrated to predict the copper concentrations under the critical (storm) flow conditions, it is more appropriate to use hardness data representative of those conditions. ***Implications:*** This is an environmentally conservative approach, as the assumption results in a more stringent standard for comparison with the model predicted water quality.

9.0 Model Results

9.1 Field Observed Existing Conditions

In Figure 10 below, the mean dissolved copper values of field samples obtained from Pinto Creek are plotted (green line with diamonds) by the river mile distance from the river's mouth at Lake Roosevelt. The "+" and "-" symbol situated above and below each sampling site (diamond), indicates the range of dissolved copper values in the analytical data for that site. The magenta squares, shows the chronic Aquatic & Wildlife standard based on the mean hardness observed at that sampling site (with the exception of the USGS gage below Haunted Canyon where the criteria was based on a "storm flow" hardness of 150 mg/L). All observed data (green line with diamonds) above the magenta line exceed the chronic criteria. It should be noted that the "y" axis data are plotted on a logarithmic scale to improve legibility at lower concentrations, while still depicting the very high values.

Figure 10

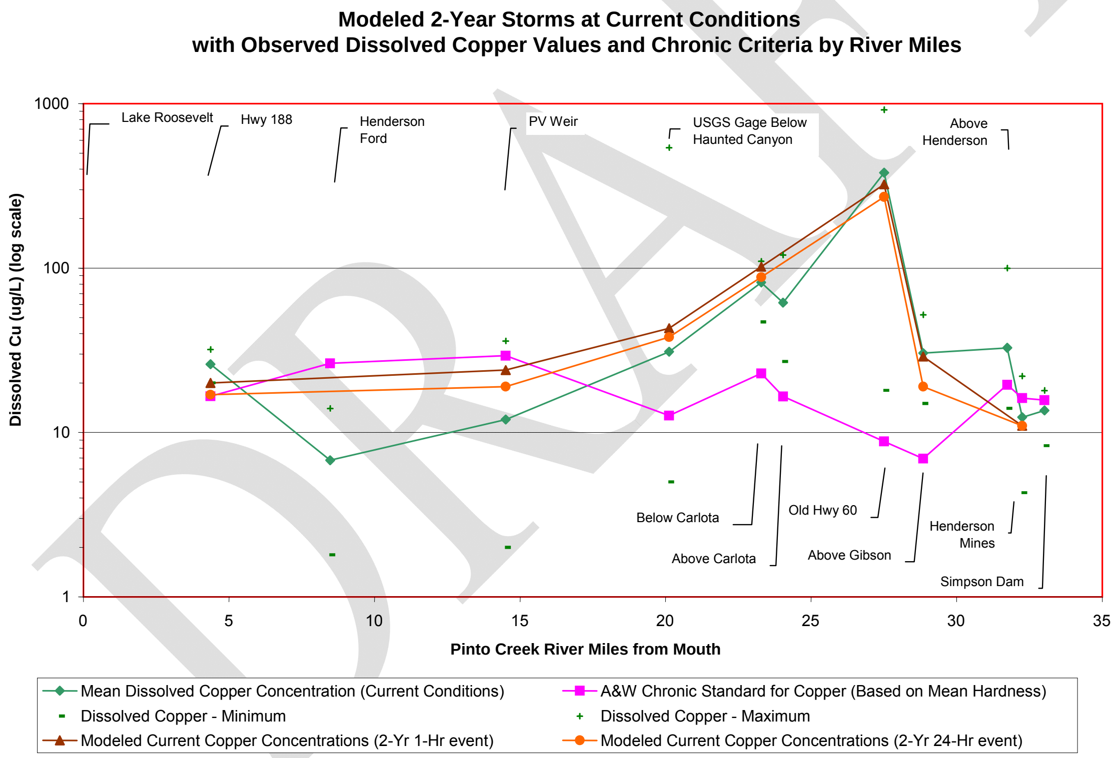


Initial water quality in the headwaters (mile 33+), continuing downstream past the “Ellis Ranch” tributary (mile 32.31), and continuing to the sample site above the Henderson Mines (mile 32.25), frequently appears to meet the existing chronic criteria. Beginning at the Henderson Mines, increased copper concentrations combined with decreased hardness levels cause the stream to exceed the default chronic A&W water quality standard. Dissolved copper increases markedly after the confluence with the Gibson tributary (mile 28.8), with peak observed mean concentration occurring at the sample site located at the old US Highway 60 crossing (mile 27.51). From this point downstream, observed dissolved copper concentrations gradually decrease, with the exception of a slight increase thru the Carlota / Cactus copper ore deposit. Hardness, and thus chronic criteria, generally increase through this reach as well. Mean copper concentrations are generally low and normally meet the chronic standard from the USGS Pinto Valley weir (mile 14.51) to Lake Roosevelt. The apparent increase in copper from the Henderson Ford site (mile 8.48) to the site at the AZ SR 188 Highway (mile 4.37) is an artifact of stream flow condition sampling bias. Data collected from the Henderson Ford site represents generally low-flow conditions when little copper was being delivered to the stream; whereas the SR 188 site is exclusively representative of higher storm-flow conditions when copper delivery and transport to the stream is significantly higher.

9.2 Model Calibration to Current Conditions

In Figure 11 below, the HSPF model output for current watershed conditions (with all known human and natural sources contributing today), has been added to the previous exhibit. The predicted copper concentration for the 2-year, 1-hour (brown line with triangles) and 2-year, 24-hour (orange line with circles) storm events are depicted here. This graphic illustrates that the HSPF model exhibits a good calibration to the field data collected during storm-flow conditions. The departure of the model results to observed data in the Henderson Mines area is primarily due to fact that no model output was available to plot in that area. The modeled departures in the vicinity of the Pinto Valley weir and Henderson Ford are largely a result of field data collected under lower flow conditions than the modeled storm runs. Additional detailed information on hydraulic and chemical calibrations is included in the modeling report in Appendix B.

Figure 11

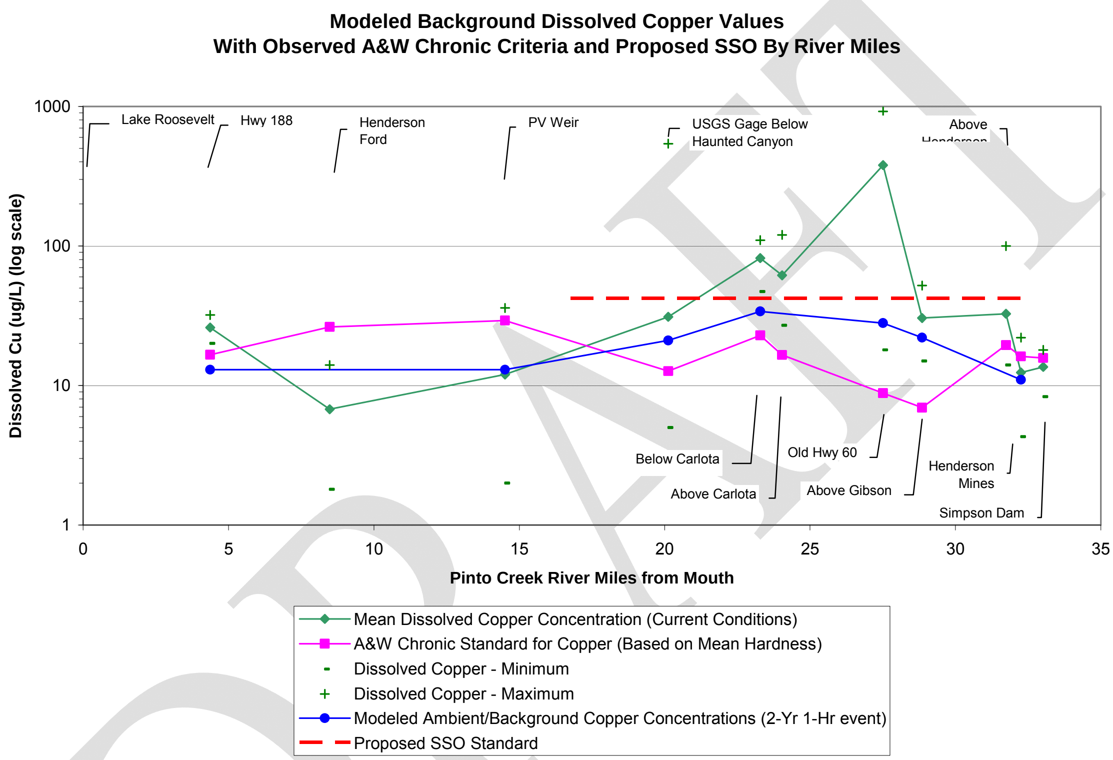


9.3 Modeling Natural Background Conditions

The calibrated model was then used to simulate a natural condition scenario by conceptually reverting the mine sites to assumed pre-anthropogenic conditions, as discussed in further detail in the modeling report in Appendix B. The pre-anthropogenic, natural condition model output for the most frequent precipitation event (2-year, 1-hour) is shown in Figure 12 below (blue line with circles). The model results for pre-anthropogenic conditions indicate that natural background conditions alone would be expected to exceed the chronic criteria (magenta line with squares) from near the Henderson Mines to below the USSG gage below Haunted Canyon. The dashed line indicates the proposed SSS.

As can also be noted from this chart, the model predicts that the actual dissolved copper concentrations observed today (green line with diamonds) can be substantially reduced by remediation of the abandoned/inactive mines.

Figure 12

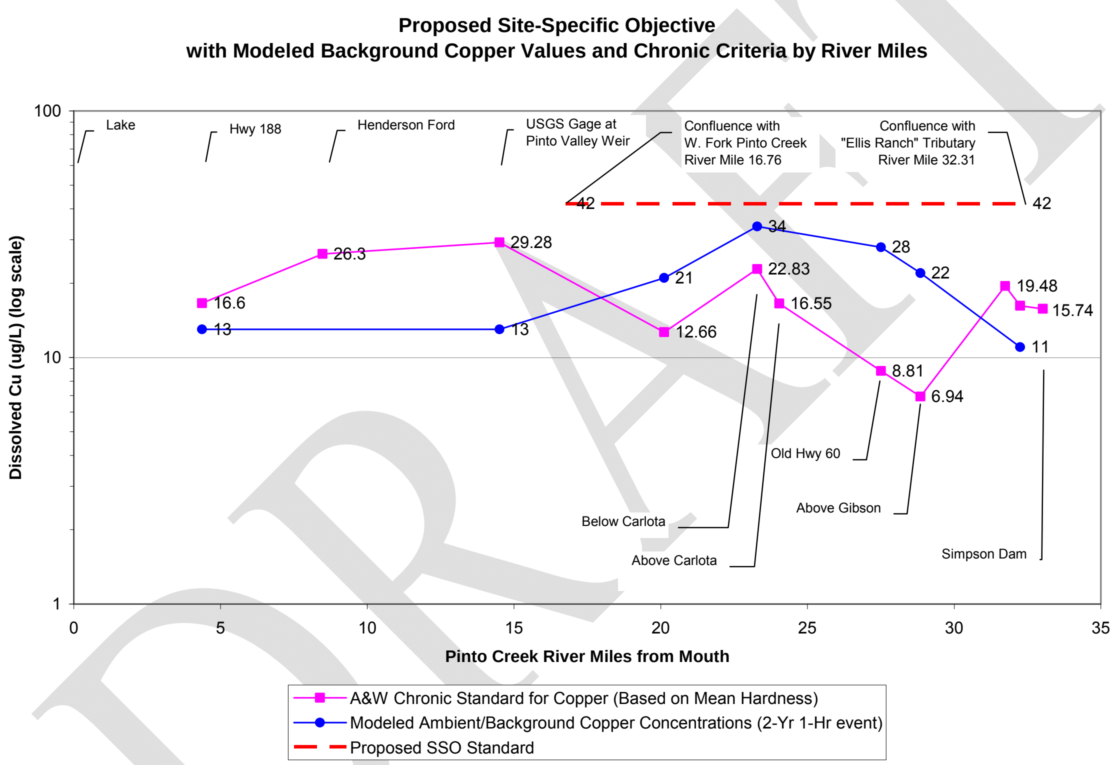


10.0 Derivation of the Site-Specific Standard for Pinto Creek

SSS Determination Step 1 – <u>Compare the Default Water Quality Criteria to the Model Predicted Natural Water Quality</u>

The model prediction of dissolved copper concentration for the most frequent event modeled, which is 2-yr, 1-hr event (refer to Table 7-3 in the MPI February 2006 Model report) is plotted on the chart below (Figure 13) vs. the river mile location. Also plotted are the default chronic A&W copper criteria for each location based on the mean hardness observed at each location.

Figure 13



SSS Determination Step 2 – <u>Define the length of the SSS reach by identifying the specific reach which is "naturally" greater than the default standard</u>

Determine the SSS reach by identifying the stream reach(s) where the model indicates natural background concentrations exceed the default standard.

SSS Determination Step 3 – <u>Define the new SSS criterion for the reach by estimating the peak natural condition concentration.</u>

Determine the level for the SSS by selecting the copper concentration from the station with the highest predicted natural background concentration. To this value add the average standard deviation of copper from sites identified as representing natural background.

This value is derived from the pre-anthropogenic, natural condition HSPF model output for the 2-year, 1-hour precipitation event and is depicted in Figure 14 above (blue line with circles). As can be noted from this chart, the maximum natural background concentration is predicted to occur just downstream of the Cactus / Carlota ore body. Downstream of this point copper concentrations decrease, primarily due to dilution from major tributaries with low natural copper levels such as Powers Gulch, Haunted Canyon, Mowing Machine Basin, and the West Fork Pinto Creek.

While ADEQ has reasonably high confidence in the model predictions, it must be recognized that all models are necessarily simplified datasets and algorithms simulating the real world. Therefore, all models are in error to some degree. Since the input data had to be simplified and reduced to fewer values, the true variability in the model input parameters is not accounted for in the raw model output.

One of the most tangible examples of input variability is in the water quality samples judged to be representative of natural background conditions. In Table 3 below, those sites deemed as background and having more than one sample are tabulated. Based on analysis of this data, an average standard deviation of the natural background copper data is 7.73 ug/L.

TABLE 3 - ***Calculation of Standard Deviation from Natural Background Sampling Sites***

Site ID	Site Name	Sample Type	n	Min	Max	Mean	STD
102647	ELLIS RANCH TRIBUTARY – ABOVE FOREST ROAD 349	Schist/Granodiorite – Background	25	36	96	56.92	12.36
102648	ELLIS RANCH TRIBUTARY – AT FOREST SERVICE ROAD 349	Schist/Granodiorite – Background	2	26	26	26	0
102654	UNNAME TRIB TO PINTO CREEK (UP6) - AT FOREST ROAD #2	Schist - Background	30	18	32	24	3.30
102655	MEAD CANYON - BELOW MF RANCH	Schist - Background	19	23	67	37.84	8.66
101072	HAUNTED CANYON - CARLOTA WEIR	Mixed Lithology – Background	47	5.4	23	13.29	7.42
102667	MOWING MACHINE BASIN TRIBUTARY - NEAR PINTO CREEK	Mixed Lithology – Background	3	12	27	19	7.55
102668	JK MOUNTAIN TRIBUTARY - ABOVE WEST FORK PINTO CREEK	Mixed Lithology – Background	2	18	28	23	7.07
102941	UNNAMED TRIB TO PINTO CREEK (UPA) - ABOVE RIPPER SPRING TRIBUTARY	Mixed Lithology – Background	2	20	30	25	7.07
102657	FIVE POINT MOUNTAIN TRIBUTARY - 60W3	Granite – Background	4	46	72	59.25	10.81
102687	UNNAMED TRIB TO UF1 (UUF) - 60W2	Granite – Background	4	22	50	30.5	13.18
102688	UNNAMED TRIB TO 5 PT MTN TRIB (UF1) - 60W1	Granite – Background	4	19	33	24.5	6.03
102689	UNNAMED TRIB TO 5 PT MTN TRIB (UF2) – AUTO SAMPLER SITE	Granite – Background	59	32	72	53.85	9.32
			201	5.4	96	32.76	**7.73 Avg STD**

A model cannot be more accurate than the data input to the model. While there are many model input variables whose absolute values are unknown, this simple analysis of the above data set is a measured and conservative estimate of the maximum model accuracy. In other words, the output of estimated copper concentrations from the model should be assumed to have and error of at least ± 7.73 ug/L.

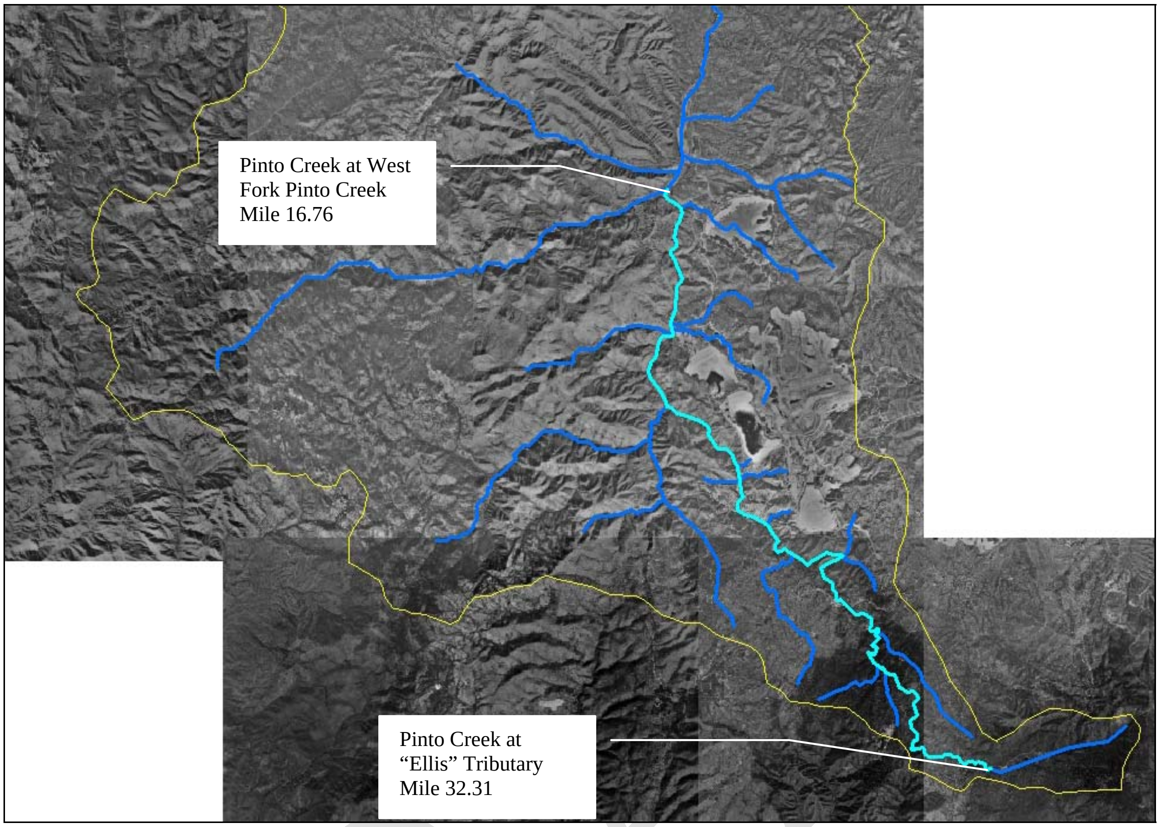
In arriving at a final recommended copper criterion for the SSS reach, ADEQ considers it prudent and reasonable to account for natural variation in the input data by adding this value to model output. Therefore ADEQ has elected to add 8 ug/L to the maximum predicted model output of 34 ug/L to arrive at the recommended dissolved copper SSS numeric criterion of 42 ug/L.

11.0 Recommended Site-Specific Standard for Pinto Creek

The recommended dissolved copper criteria applicable to the SSS reach of Pinto Creek is 42 ug/L (or 0.042 mg/L). This is a static value, and therefore, is not adjusted for variations in hardness. This value is equal to the estimated maximum natural background concentration of dissolved copper in Pinto Creek thru the identified SSS reach.

The recommended stream reach to apply the SSS begins on Pinto Creek at the confluence with the "Ellis Ranch" tributary (river mile 32.31) located at North latitude 33º 19' 26.7", West longitude 110º 54' 57.5", continuing downstream 15.55 river miles to the confluence with the West Fork Pinto Creek (river mile 16.76) located at North latitude 33º 27' 32.3", West longitude 111º 0' 19.7"(Figure 14).

Figure 14 – Location of Site-Specific Standard Reach



12.0 Implementation Issues

12.1 Protection of Designated Uses

USEPA guidance suggests that an SSS should address the question of whether the SSS is protective of all designated uses (USEPA 2005, p7). As shown previously in Table 2, the proposed SSS of 42 ug/L dissolved copper is substantially lower than the applicable standards for Fish Consumption, Full Body Contact, Agricultural Irrigation, and Agricultural Livestock Watering uses. Therefore the SSS is fully protective of these designated uses.

The Aquatic and Wildlife criterion is the only designated use with a water quality standard more stringent than the proposed SSS. However, USEPA guidance suggests that *"Criteria which are based on truly natural conditions (i.e., conditions absent human impacts) inherently protect the aquatic life uses that have "naturally" existed in the waterbody"* (USEPA, 2005, p9). Therefore the SSS is fully protective of the aquatic life use as well.

12.2 Threatened and Endangered Species

According to the EIS for the Carlota Project (USFS, 1997, pF-3), two endangered species are listed for the Pinto Creek area, the Arizona Hedgehog Cactus (Figure 15), and the Lesser Long-nosed Bat (Figure 16). ADEQ has not evaluated what, if any, impacts the modest change in dissolved copper criteria for Pinto Creek may have on any Threatened and Endangered (T&E) Species. ADEQ believes that the rationale applied to aquatic life (i.e., that naturally occurring levels of pollutants are adequately protective), is reasonably extended to other wildlife uses as well. For that reason, ADEQ believes that uses by these T&E species are inherently protected by the proposed SSS.

Figure 16 Lesser Long-nosed Bat Photo: US Fish & Wildlife Service

Figure 15 Arizona Hedgehog Cactus Photo: US Fish & Wildlife Service

12.3 Non-point sources

ADEQ will prepare an implementation plan following or concurrent with the Phase II TMDL for Pinto Creek. However, it should be recognized that significant improvements are already underway in the watershed.

The Gibson Mine is the single largest copper source in the watershed impacting Pinto Creek (Figure 17). It is estimated that the Gibson Mine represents over 90% of the dissolved copper load in the upper portion of the watershed. In recognition of this, ADEQ has already approved two Water Quality Improvement (Section 319) grants totaling $710,277 to reduce pollutant loads from non-point sources at the Gibson Mine site (note that one of the grants ($140,171) addresses discharges to the Mineral Creek watershed only).

Figure 17 - Gibson Mine - Lower PLS Pond and Stock Piles

In addition to the remedial activities funded by the 319 grants, the Gibson Mine owners are addressing other point-sources on the site thru Arizona's Aquifer Protection Program. These include closure of several process ponds and assessing the impact of former In-Situ underground leaching facilities. Additional remedial work on the Gibson site is also a condition of the NPDES permit issued to the Carlota Copper Co. Although it is yet to be seen how effective the aggregate of the measures will be, the combination of the three remedial activities should substantially reduce copper loading to Pinto Creek.

Other known human-caused sources of copper in the watershed include at least five other inactive/abandoned copper mines including; Ellis, Henderson, Bronx, Yo Tambien, and Old Highway 60 mines. The ownership of these historic mines has not been determined conclusively, however it is currently believed that most are located on US Forest Service lands. Regardless of ownership, remediation of these sites will need to be pursued in the implementation plan. Other land disturbances, such as wildfire, road-cuts, grazing, ranching, or timber harvesting, at least theoretically, could influence copper loadings, but have not been identified as significant contributors.

12.4 Point sources

The only NPDES permitted point-sources to Pinto Creek are the BHP-PVO mine (Figure 18) and the proposed Carlota mining project, recently acquired by Quadra Mining Ltd. The need for any changes to the AZPDES permits for these facilities as a result of the SSS will be evaluated during the permit renewal processes.

Figure 18 – BHP-PVO NPDES Outfall 005

13.0 Public Participation

13.1 Public Meetings

Public participation has been an important factor in the development of the Pinto Creek Phase II TMDL and pre-development of this SSS. Since the conclusion of EPA's Phase I TMDL, ADEQ has held three public meetings to disseminate information discuss issues and receive questions, comments and suggestions from the public.

The meetings were held: February 1, 2001 and December 15, 2003, at the BHP-PVO Training Facility, and July 22, 2004 at City Hall, Globe AZ.

The meetings were well attended and the audience comprised a broad range of interests. Groups in attendance included: Arizona Center for Law in the Public Interest, Arizona Department of Environmental Quality, Arizona Fish & Game Dept, BHP Copper Inc, Bryan Cave, Carlota Copper Co, Citizens for the Preservation of Powers Gulch and Pinto Creek, Friends of Pinto Creek, Grand Canyon Chapter of the Sierra Club, Haley & Aldrich, Maricopa Audubon Society, Mineral Policy Center, National Wildlife Federation, People for the West, Phelps Dodge, Sun City Hikers, Tonto National Forest, Western Mining Action Project and other local parties and land owners.

13.2 Opportunity to Comment

In addition to the pre-development meetings, ADEQ anticipates at least one additional public meeting specifically on the SSS, to be held in the Globe area.

The SSS is also expected to be incorporated into the Triennial Review of the surface water quality standards rule package. Additional public notice and opportunity for public review and comment are provided by this rulemaking process.

13.4 Availability of Information

The project files and administrative record for this SSS are available for inspection by appointment at the ADEQ offices located at 1110 W Washington St, Phoenix, Arizona 85007. Phone (602) 771-2300 or, toll free in Arizona, (800) 234-5677

14.0 References

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APPENDIX A

Water Quality Data and Monitoring Site Information

APPENDIX B

Pinto Creek Phase II TMDL Modeling Report - Malcolm Pirnie
February, 2006